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A LABORATORY EVALUATION OF NON-SHRINK GROUT

MATERIALS INFORMATION
ENGINEERING MATERIALS OFFICE

A LABORATORY EVALUATION OF NON-SHRINK GROUTS

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MINISTRY OF TRANSPORTATION AND COMMUNICATIONS

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SUMMARY

Eleven non-shrink grouts were tested for setting time, early volume change, chloride permeability, drying shrinkage, compressive strength, freeze-thaw durability and resistance to salt scaling. These tests were used to determine the suitability of the non-shrink grouts for use as bedding for bridge bearings and for filling anchor core-holes.

Six of the eleven grouts were found to be suitable for the applications.

INTRODUCTION

Non-shrink grouts are used as bedding for bridge bearings. They must be workable during placement and strong and durable after setting. Durability in the presence of deicing salts is very important as most bearings are located under expansion joints which often leak in service.

Grouts listed in the designated sources list DS: 133, Grout, Non-Shrink are used for the bedding and for filling anchor core-holes. Since the resistance of these grouts to salt scaling was unknown, the Ministry Bridge Bearings Committee requested the Concrete Section to provide a list of proprietary grouts that would be suitable for the application (see Appendix A). The requirements are that the grout be non-shrink, non-staining (non-ferrous) and resistant to salt scaling. In addition, the draft OPSS 922, Construction Specification for the Installation of Bearings requires that the compressive strength of the grout be a least 35 MPa at 7 days as tested on 50 mm cubes.

This report describes a series of laboratory tests carried out on eleven proprietary grouts to determine their suitability for inclusion on the Ministry's designated sources list for non-shrink grouts (D.S. 133). The grouts were tested for setting time, shrinkage, chloride permeability, strength and durability. The report describes the test results and evaluates the suitability of the grouts for bedding bridge bearings. Non-shrink grouts are also used to anchor dowel bars. Suitability for this purpose depends mainly on the results of pull-out tests which are not described here, however, grouts which are acceptable for bedding bridge bearings are also likely to be acceptable for anchoring dowel bars.

The evaluation was carried out between August 1986 and April 1987.

MATERIALS TESTED

Eleven proprietary grouts were included in the evaluation program. Table A shows the trade name, the manufacturer and the mix proportions recommended by the manufacturer for each of the grouts.

TEST PROCEDURES

Each grout was tested for setting time (ASTM C403-70), early volume change (ASTM C827-82), chloride permeability (AASHTO T277-831I), drying shrinkage (ASTM C157-80), compressive strength (CAN3-A5-M83), freeze-thaw durability (ASTM C666-84, Proc. A) and salt scaling (MTC Test Method, see Appendix B).

A batch of each grout was mixed in a concrete mixer and was of sufficient volume to fabricate all specimens for all the tests. The mix proportions (dry grout to water ratio) were as shown in Table A.

Two small batches were made of each grout, one to produce a plastic mix and the other a pourable mix to determine the water to grout ratios for these consistencies. A mix having a flow of 100 ± 5% was defined as a plastic mix while a mix having a flow of 140 ± 5% as a pourable mix. The water to grout ratio and the flow are shown in Table A-1. These water to grout ratios for pourable mixes (Table A-1) may be compared to those recommended by the manufacturers (Table A) for pourable mixes.

TEST RESULTS

The results of all the tests are shown in Tables B to F.

SETTING TIME (TABLE B)

There was a considerable variation in the initial and final setting times. Of the non latex grouts, Master Builders Set Non-Shrink Grout had the shortest initial setting time (1 h oo min.) and CPD Non-Shrink Grout the longest (7 h oo min.). The CPD Non-Shrink Grout with Latex reached the initial setting time at 10 h 30 min. The shortest and the longest final setting time was also for the same grouts. Master Builders Set Non-Shrink Grout reached the set at 2 h 36 min., CPD Non-Shrink Grout at 8 h 39 min. and CPD Grout with Latex at 12h 12 min. The setting times were determined at the standard laboratory room temperature of 23°C ± 2°C. Lower temperatures will extend and higher temperatures will reduce the times. However, even when the grout is Master Builders Set Non-Shrink Grout and the air temperature is higher than 23°C, there should still be sufficient time after mixing to place and finish a bedding.

EARLY VOLUME CHANGE (TABLE B)

This test determines the volume change during the period of setting and hardening. Grouts referred to as "non-shrink grouts" shrink considerably less than ordinary grouts. They contain an agent such as aluminum powder to cause expansion and counteract the shrinkage. The early volume changes reported in Table B are as measured on the top of a 100 x 200 mm cylinder. Some of the grouts tested (Masterflow 713, Sonogrout, Sternson M-Bed Superflow, Meadows V-1 and V-3) shrank the others expanded during the test. The highest shrinkage was produced by the two Meadows grouts (-0.555, -0.556) followed by Sternson M-Bed Superflow (-0.305), Sonogrout (-0.269) and Masterflow 713 (-0.137). Shrinkages of the order produced by the Meadows grouts and Sternson M-Bed Superflow grout are likely to have an adverse effect on the performance of anchorages, but it is doubtful that this shrinkage or expansion is important for 5-15 mm thick beddings.

CHLORIDE PERMEABILITY (TABLE B)

In seven out of the eleven grouts, the rapid chloride permeability test had to be terminated before the standard exposure time (360 min.) because of the high temperature reached during the test (>88°C). Eight of the grouts were found to have high permeability (>4000 Coulombs) by this test. Of the other three grouts, Master Builders Set Non-Shrink Grout (3958 Coulombs), Sonogrout (3427 Coulombs) and CPD Non-Shrink Gout with Latex (2174 Coulombs) can be considered to have only a moderate permeability according to AASHTO T277-83I. However, this characteristic is not of great importance for the beddings and anchor core-holes as long as the steel in the bearings and the anchors is protected.

DRYING SHRINKAGE (TABLE C)

The 75 x 75 x 285 mm prisms were stored in moulds for the first 24 h and then in lime saturated water for 27d followed by storage at 23 ± 2°C and 50 ± 4% R.H. Table C shows the change in length at 3, 7, 14 and 28 days of the dry storage based on the initial measurement made at the time of removal from the moulds. Prisms made

of a conventional air entrained mortar with a w/c ratio of 0.50 and air content of 11% shrink by approximately 0.180 at 28d. None of the grouts exhibited higher drying shrinkage than 0.180% at 28d. All shrank less than the conventional mortar with the CPD Non-Shrink Grout (-0.062) and Sonogrout (-0.069) exhibiting the least shrinkage.

COMPRESSIVE STRENGTH (TABLE D)

OPSS 922, Construction Specification for the Installation of Bearings requires that the strength be at least 35 MPa at 7d. All the grouts tested with the exception of CC Chemicals In-Pact (34.8 MPa), CPD Non-Shrink Grout (32.9 MPa) and CPD Non-Shrink Grout with Latex (28.4 MPa) comply with the requirement. The lowest strength at 28d was produced by CPD Non-Shrink Grout with Latex (37.0 MPa), the others produced a compressive strength of 41.8 to 77.1 MPa. A decrease in the water to grout ratio to produce a somewhat stiffer than pourable consistency would probably increase the strength of CC Chemicals In-Pact and CPD Non-Shrink grouts to at least 35.0 MPa at 7d.

Although compressive strength is a measure of the suitability of anchor grouts, the most important is pull-out strength. However, this property was not evaluated in this test program.

FREEZE-THAW DURABILITY (TABLE E)

Two products, Meadows V-1 and V-3 exhibited very poor durability. The prisms made of these two grouts expanded excessively, had high mass loss and very low durability factors. Although the relative dynamic modulus of Sternson M-Bed Superflow grout was satisfactory (92.7%), one of the prisms developed a crack across the width of the prism. Each of the two prisms showed a relatively high expansion. The CPD Non-Shrink Grout with Latex prisms developed moderate surface scaling and one of the prisms cracked longitudinally during the exposure. All the other grouts performed satisfactorily in the test although the CC Chemicals In-Pact grout prisms showed some signs of disintegration.

SALT SCALING RESISTANCE (TABLE F)

There is no acceptable guideline for the resistance of grout to the salt scaling. The Ministry has developed such a guideline for concrete and it is a mass loss of 0.8 kg/ m2 of the area exposed to scaling. However, this guideline acceptance criterium does not apply to pastes or grouts. it is believed that the acceptance criterium is too severe for grouts. A mass loss of 1.0 kg/m2 or even somewhat higher would be more appropriate as an acceptance guideline for these types of materials. This would reject four of the eleven grouts tested, three of which developed very severe scaling (Meadows V-1 and V-3, Sternson M-Bed Superflow), one high scaling (Master Builders Set Non-Shrink Grout) and one moderately higher (CC Chemicals In-Pact). These grouts with the exception of Master Builders Set Non-Shrink Grout showed also poor resistance to the freeze-thaw exposure (Table E).

GENERAL DISCUSSION

The use of non-shrink grouts in the Ministry work is not extensive but is usually in critical applications such as seats for bridge bearings and anchors for barrier walls.

In most Ministry applications, the grout is exposed to the action of freezing and thawing and deicing salt so the grout must be resistant to this exposure. Another important property is a pull-out strength when a grout is used for anchorage. This strength depends on the bond strength of the grout to the anchor hole face, sheer strength of the grout and embedment length.

Compressive strength, freeze-thaw durability, resistance to salt scaling and pull-out strength depend on the water-grout ratio. In two cases, the tests were carried out at a significantly higher grout-cement ratio (Table A) than that necessary to produce a pourable mix (Table A-1). One of the two cases was the Master Builders Set Non-Shrink grout which failed the salt scaling requirement. The water-grout ratio of this grout mix (recommended by the manufacturer) was 0.198 while a pourable mix can be made with a water-grout ratio of 0.17. There is no doubt that this is largely responsible for the higher than acceptable mass loss in the salt scaling test. For this reason, the salt scaling resistance of this grout is changed to "acceptable". The other grout is Sternson M-Bed Superflow. Here again, the water-grout ratio was higher by 0.03 than needed to produce pourable mix. However, the mix exhibited very poor performance in the salt scaling test and it is unlikely to have adequate salt scaling resistance at a somewhat lower water to grout ratio.

CPD Non-Shrink Grout marginally failed the strength requirement for bridge bearing beddings. However, its water-grout ratio was also a little higher than necessary for a pourable mix and it developed sufficiently high strength at 28d, therefore it is accepted. The more so that a pourable consistency is not used for the application (bearing beddings).

Some applications require mixes of plastic consistency (bearing seats), other mixes of pourable consistency (anchor holes). Most of non-shrink grouts are used for anchor holes so the list of designated sources for non-shrink grouts should contain only grouts that comply with the requirements for strength and durability as tested on pourable mixes.

Table G summarizes the acceptability of each of the grouts tested. It shows the grouts that are acceptable for the listing in the designated sources list DS:133 as well as those which failed the tests and which property they failed.

CONCLUSIONS

Of the eleven proprietary non-shrink grouts tested, only six developed adequate strength and durability. The others fail the durability requirement(s) and two of them also fail the strength requirement. Table G shows the five unacceptable and the six acceptable products.

RECOMMENDATIONS

It is recommended that the current list of designated sources be revised to include only the following products:

Masterflow 713 Grout
Master Builders Set Non-Shrink Grout
Sika Grout 212
Sternson M-Bed Standard Grout
CPD Non-Shrink Grout
Sonogrout

All these grouts are suitable for areas exposed to freeze-thaw and deicing salt.

TABLE A GROUTS TESTED

PRODUCT NAME	MANUFACTURE	RECOMMENDED MIX PROPORTIONS WATER : GROUT RATIO
MASTERFLOW 713 GROUT	MASTER BUILDERS CO.	25 kg DRY GROUT TO 4.25 L WATER 0.170
MASTER BUILDERS SET NON SHRINK GROUT	MASTER BUILDERS CO.	22.7 kg DRY GROUT TO 4.5 L WATER 0.198
MEADOWS V-3 GROUT	W.R.MEADOWS OF CAN. LTD.	21.9 kg DRY GROUT TO 4.1 L WATER 0.187
MEADOWS V-1 GROUT	W.R.MEADOWS OF CAN. LTD.	21.9 kg DRY GROUT TO 4.1 L WATER 0.187
SIKA GROUT 212	SIKA CANADA INC.	25 kg DRY GROUT TO 4.25 L WATER 0.170
STERNSON M-BED SUPER FLOW GROUT	STERNSON LTD.	25 kg DRY GROUT TO 4.25 L WATER 0.170
STERNSON M-BED STANDARD GROUT	STERNSON LTD.	25 kg DRY GROUT TO 4.5 L WATER 0.180
CC CHEMICALS IN-PAKT PRE-MIX GROUT	C.C. CHEMICALS LTD.	* 30 kg DRY GROUT TO 5.5 L WATER 0.183
CPD NON-SHRINK GROUT	CONST. PRODUCTS DISTRIBUTION SERVICES	25 kg DRY GROUT TO 4.0 L WATER 0.160
CPD NON-SHRINK GROUT WITH LATEX	CONST. PRODUCTS DISTRIBUTION SERVICES	25 kg DRY GROUT TO 4.0 L LATEX ** 0.160
SONOGROUT	SONNEBORN BUILDING PRODUCTS	25 kg DRY GROUT TO 3.3 L WATER 0.132

* DETERMINED IN THE LAB. BY THE FLOW TEST
** LATEX : GROUT RATIO

TABLE A-1 WATER TO GROUT RATIOS FOR PLASTIC AND POURABLE MIXES

PRODUCT NAME	PLASTIC MIX (FLOW 100±5%)		POURABLE MIX (FLOW 140±5%)	
	FLOW	W/G RATIO	FLOW	W/G RATIO
MASTERFLOW 713 GROUT	96	0.15	138	0.17
MASTER BUILDERS SET NON SHRINK GROUT	96	0.15	137	0.17
MEADOWS V-3 GROUT	104	0.16	138	0.20
MEADOWS V-1 GROUT	99	0.17	139	0.20
SIKA GROUT 212	97	0.15	136	0.17
STERNSON M-BED SUPER FLOW GROUT	102	0.12	136	0.14
STERNSON M-BED STANDARD GROUT	98	0.16	136	0.19
CC CHEMICALS IN-PAKT PRE-MIX GROUT	105	0.16	140	0.18
CPD NON-SHRINK GROUT	99	0.13	144	0.15
CPD NON-SHRINK GROUT WITH LATEX	N. T.	N. T.	N. T.	N. T.
SONOGROUT	96	0.13	138	0.15

N. T. = NOT TESTED

NOTE: MIXING AND FLOW TEST IN ACCORDANCE WITH CAN3-A5-M83

TABLE B **SETTING TIME,EARLY VOLUME CHANGE AND CHLORIDE PERMEABILITY TEST RESULTS**

PRODUCT NAME	SETTING TIME				EARLY VOLUME CHANGE	CHLORIDE PERMEABILITY
	INITIAL		FINAL			
	HR.	MIN.	HR.	MIN.	%	COULOMBS
MASTERFLOW 713 GROUT	3	33	5	15	-0.137	7991 * (248)
MASTER BUILDERS SET NON SHRINK GROUT	1	00	2	36	0.127	3958
MEADOWS V-3 GROUT	3	58	5	07	-0.556	5126 * (150)
MEADOWS V-1 GROUT	3	08	4	09	-0.555	8334 * (248)
SIKA GROUT 212	4	45	6	15	1.359	6502 * (171)
STERNSON M-BED SUPER FLOW GROUT	2	33	3	28	-0.305	6067 * (274)
STERNSON M-BED STANDARD GROUT	4	54	6	24	2.530	6750 * (190)
CC CHEMICALS IN-PAKT PRE-MIX GROUT	4	42	6	20	4.840	6439
CPD NON-SHRINK GROUT	7	08	8	39	2.050	9404 * (300)
CPD NON-SHRINK GROUT WITH LATEX	10	30	12	12	2.470	2174
SONOGROUT	4	56	6	20	-0.269	3427

* ( ) = TERMINATION TIME (MIN.)

TABLE C DRYING SHRINKAGE TEST RESULTS

PRODUCT NAME	SHRINKAGE (%)			
	3 DAY	7 DAYS	14 DAYS	28 DAYS
MASTERFLOW 713 GROUT	* -0.071	-0.096	-0.121	-0.159
	* -0.069	-0.097	-0.122	-0.161
	* -0.071	-0.096	-0.123	-0.159
AVE.	* **-0.070**	**-0.096**	**-0.122**	**-0.160**
MASTER BUILDERS SET NON SHRINK GROUT	0.046	0.011	-0.021	-0.059
	0.044	0.009	-0.024	-0.062
	0.040	0.007	-0.026	-0.065
AVE.	**0.043**	**0.009**	**-0.024**	**-0.062**
MEADOWS V-3 GROUT	-0.022	-0.050	-0.067	-0.094
	-0.023	-0.052	-0.070	-0.095
	-0.024	-0.052	-0.068	-0.095
AVE.	**-0.023**	**-0.051**	**-0.068**	**-0.095**
MEADOWS V-1 GROUT	-0.016	-0.038	-0.068	-0.082
	-0.018	-0.042	-0.068	-0.085
	-0.018	-0.042	-0.070	-0.074
AVE.	**-0.017**	**-0.041**	**-0.069**	**-0.080**
SIKA GROUT 212	-0.046	-0.085	-0.113	-0.154
	-0.048	-0.086	-0.114	-0.154
	-0.048	-0.084	-0.114	-0.154
AVE.	**-0.047**	**-0.085**	**-0.114**	**-0.154**
STERNSON M-BED SUPER FLOW GROUT	-0.028	-0.058	-0.088	-0.111
	-0.029	-0.057	-0.087	-0.110
	-0.030	-0.059	-0.088	-0.111
AVE.	**-0.029**	**-0.058**	**-0.088**	**-0.111**
STERNSON M-BED STANDARD GROUT	-0.069	-0.110	-0.135	-0.166
	-0.065	-0.107	-0.135	-0.166
	-0.069	-0.110	-0.136	-0.166
AVE.	**-0.068**	**-0.109**	**-0.135**	**-0.166**
CC CHEMICALS IN-PAKT PRE-MIX GROUT	-0.029	-0.057	-0.083	-0.108
	-0.028	-0.054	-0.081	-0.105
	-0.028	-0.053	-0.081	-0.103
AVE.	**-0.028**	**-0.055**	**-0.082**	**-0.105**
CPD NON-SHRINK GROUT	-0.053	-0.091	-0.126	-0.150
	-0.053	-0.092	-0.128	-0.156
	-0.054	-0.095	-0.130	-0.156
AVE.	**-0.053**	**-0.093**	**-0.128**	**-0.154**
CPD NON-SHRINK GROUT WITH LATEX	0.037	0.018	0.001	-0.029
	0.038	0.019	0.002	-0.029
	0.039	0.021	0.004	-0.025
AVE.	**0.038**	**0.019**	**0.002**	**-0.028**
SONOGROUT	N. T.	-0.039	-0.054	-0.067
		-0.038	-0.054	-0.068
		-0.038	-0.057	-0.071
AVE.		**-0.038**	**-0.055**	**-0.069**

* 4 DAY READING

N. T. = NOT TESTED

TABLE D COMPRESSIVE STRENGTH TEST RESULTS

PRODUCT NAME	COMPRESSIVE STRENGTH (MPa)			
	1 DAY	3 DAYS	7 DAYS	28 DAYS
MASTERFLOW 713 GROUT	27.4	39.1	49.3	59.9
	27.2	39.8	49.2	58.1
	27.5	40.4	49.2	59.0
AVE.	27.4	39.8	49.2	59.0
MASTER BUILDERS SET NON SHRINK GROUT	22.3	37.4	41.7	50.5
	21.0	35.5	43.3	49.2
	22.5	36.5	39.6	51.0
AVE.	21.9	36.5	41.5	50.2
MEADOWS V-3 GROUT	37.1	49.8	55.5	70.6
	38.6	48.7	56.0	65.6
	38.0	50.6	54.4	65.7
AVE.	37.9	49.7	55.3	67.3
MEADOWS V-1 GROUT	47.6	49.9	64.9	71.9
	46.9	55.8	61.6	73.3
	47.4	55.5	64.3	71.0
AVE.	47.3	53.7	63.6	72.1
SIKA GROUT 212	28.0	45.5	50.5	57.4
	27.7	45.2	51.0	60.1
	26.7	45.6	50.8	58.0
AVE.	27.5	45.4	50.8	58.5
SUPER FLOW GROUT	40.3	51.7	50.9	70.4
	41.4	51.4	56.7	70.8
AVE.	40.1	51.6	54.6	70.2
STERNSON M-BED STANDARD GROUT	24.1	36.1	43.7	52.7
	24.8	38.8	43.5	52.9
	24.8	38.0	42.3	53.4
AVE.	24.6	37.6	43.2	53.0
CC CHEMICALS IN-PAKT PRE-MIX GROUT	23.4	31.8	35.7	46.8
	23.6	33.1	34.7	48.9
	23.1	30.3	34.1	47.9
AVE.	23.4	31.7	34.8	47.9
CPD NON-SHRINK GROUT	27.3	30.6	33 0	41.3
	26.3	31.0	32.4	41.9
	26.2	29.4	33.4	42.2
AVE.	26.6	30.3	32.9	41.8
CPD NON-SHRINK GROUT WITH LATEX	8.7	21.5	29.4	37.9
	9.4	21.4	26.3	36.8
	9.2	22.1	29.4	36.4
AVE.	9.1	21.7	28.4	37.0
SONOGROUT	45.1	53.7	58.7	77.9
	46.2	55.2	59.3	77.4
	46.8	54.2	56.7	75.9
AVE.	46.0	54.4	58.2	77.1

TABLE E FREEZE-THAW TEST RESULTS

PRODUCT NAME	FREEZE-THAW DURABILITY				
	CYCLES	LENGTH CHANGE %	WEIGHT CHANGE %	RELATIVE DYNAMIC MODULUS %	VISUAL OBSERVATIONS
MASTERFLOW 713 GROUT	340	0.015	0.06	102.5	NO SIGNIFICANT CHANGE
		0.015	0.12	102.4	
AVE.		**0.015**	**0.09**	**102.5**	
MASTER BUILDERS SET NON SHRINK GROUT	300	0.038	0.36	100.6	NO SIGNIFICANT CHANGE
		0.021	0.00	97.5	
AVE.		**0.030**	**0.18**	**99.1**	
MEADOWS V-3 GROUT	315	0.575	-19.44	40.3	SEVERE SURFACE SCALING
		0.150	-7.17	93.1	SEVERE SURFACE SCALING
AVE.		**0.363**	**-13.31**	**66.7**	
MEADOWS V-1 GROUT	232	0.241	-0.83	55.7	SEVERE SURFACE SCALING
		0.238	-1.47	61.9	SEVERE SURFACE SCALING
AVE.		**0.240**	**-1.14**	**58.8**	
SIKA GROUT 212	309	0.012	-0.14	101.9	NO SIGNIFICANT CHANGE
		0.018	-0.06	101.8	
AVE.		**0.015**	**-0.10**	**101.9**	
STERNSON M-BED SUPER FLOW GROUT	301	0.042	-0.38	95.3	NO SIGNIFICANT CHANGE CRACK ACROSS WIDTH OF BEAM
		0.049	-0.30	90.1	
AVE.		**0.046**	**-0.34**	**92.7**	
STERNSON M-BED STANDARD GROUT	316	0.015	-0.08	101.3	NO SIGNIFICANT CHANGE
		0.018	-0.14	101.2	
AVE.		**0.017**	**-0.11**	**101.3**	
CC CHEMICALS IN-PAKT PRE-MIX GROUT	312	-0.003	-0.82	98.1	MODERATE SURFACE SCALING
		0.006	-1.87	100.6	MODERATE SURFACE SCALING CORNERS DISINTEGRATED
AVE.		**0.002**	**-1.35**	**99.4**	
CPD NON-SHRINK GROUT	312	0.012	0.02	101.9	NO SIGNIFICANT CHANGE
		0.006	0.09	102.5	
AVE.		**0.009**	**0.06**	**102.2**	
CPD NON-SHRINK GROUT WITH LATEX	309	0.021	-0.53	95.5	MODERATE SURFACE SCALING
		0.032	-1.99	92.4	MODERATE SURFACE SCALING LONGITUDINAL CRACK
AVE.		**0.027**	**-1.26**	**94.0**	
SONOGROUT	313	0.032	0.20	98.4	NO SIGNIFICANT CHANGE
		0.024	0.04	97.8	
AVE.		**0.028**	**0.12**	**98.1**	

TABLE F SALT SCALING TEST RESULTS

PRODUCT NAME

SALT SCALING (MASS LOSS kg/m^2)

	CYCLES									
	5	10	15	20	25	30	35	40	45	50
MASTERFLOW 713 GROUT	0.028	0.052	0.074	0.089	0.147	0.204	0.238	0.319	0.413	0.518
	0.215	0.282	0.465	0.596	0.674	0.739	0.827	1.006	1.184	1.247
AVE.	**0.122**	**0.167**	**0.270**	**0.343**	**0.411**	**0.472**	**0.533**	**0.663**	**0.799**	**0.933**
MASTER BUILDERS SET NON SHRINK GROUT	0.026	0.062	0.107	0.177	0.335	0.518	0.824	1.155	1.411	1.594
	0.150	0.296	0.462	0.647	0.832	1.130	1.517	1.939	2.288	2.607
AVE.	**0.088**	**0.179**	**0.282**	**0.412**	**0.584**	**0.824**	**1.171**	**1.547**	**1.850**	**2.101**
MEADOWS V-3 GROUT	0.382	1.661	3.355	5.422						
	3.093	0.871	2.587	5.264	**DISCONTINUED**					
AVE.	**0.238**	**1.266**	**2.971**	**5.343**						
MEADOWS V-1 GROUT	0.073	0.450	1.284	2.256	3.329	4.518				
	0.386	1.510	2.945	4.340	5.522	6.711	**DISCONTINUED**			
AVE.	**0.230**	**0.980**	**2.115**	**3.298**	**4.426**	**5.615**				
SIKA GROUT 212	0.016	0.033	0.044	0.057	0.078	0.092	0.135	0.192	0.273	0.359
	0.026	0.037	0.049	0.072	0.096	0.113	0.164	0.211	0.280	0.362
AVE.	**0.021**	**0.035**	**0.047**	**0.065**	**0.087**	**0.103**	**0.150**	**0.202**	**0.277**	**0.361**
STERNSON M-BED SUPER FLOW GROUT	0.044	0.645	2.139	3.488	4.467	5.158				
	0.073	1.915	3.191	4.151	4.972	5.576	**DISCONTINUED**			
AVE.	**0.059**	**1.280**	**2.665**	**3.820**	**4.720**	**5.367**				
STERNSON M-BED STANDARD GROUT	0.032	0.050	0.077	0.093	0.109	0.123	0.139	0.192	0.394	0.651
	0.075	0.117	0.147	0.176	0.192	0.200	0.218	0.235	0.251	0.274
AVE.	**0.054**	**0.084**	**0.112**	**0.135**	**0.151**	**0.162**	**0.179**	**0.214**	**0.323**	**0.463**
CC CHEMICALS IN-PAKT PRE-MIX GROUT	0.462	0.767	0.847	0.949	0.981	0.992	1.028	1.110	1.139	1.161
	0.537	0.861	1.020	1.133	1.184	1.211	1.255	1.322	1.381	1.415
AVE.	**0.500**	**0.814**	**0.934**	**1.041**	**1.083**	**1.102**	**1.142**	**1.216**	**1.260**	**1.288**
CPD NON-SHRINK GROUT	0.025	0.036	0.054	0.062	0.073	0.082	0.204	0.215	0.221	0.238
	0.028	0.119	0.185	0.239	0.284	0.334	0.452	0.503	0.543	0.587
AVE.	**0.027**	**0.078**	**0.120**	**0.151**	**0.179**	**0.208**	**0.328**	**0.359**	**0.382**	**0.413**
CPD NON-SHRINK GROUT WITH LATEX	0.017	0.031	0.041	0.055	0.070	0.079	0.093	0.109	0.136	0.151
	0.021	0.032	0.041	0.054	0.071	0.088	0.100	0.109	0.115	0.125
AVE.	**0.019**	**0.032**	**0.041**	**0.055**	**0.071**	**0.084**	**0.097**	**0.109**	**0.126**	**0.138**
SONOGROUT	0.032	0.072	0.089	0.116	0.143	0.183	0.222	0.257	0.284	0.329
	0.028	0.077	0.103	0.122	0.145	0.185	0.228	0.267	0.303	0.346
AVE.	**0.030**	**0.075**	**0.096**	**0.119**	**0.144**	**0.184**	**0.225**	**0.262**	**0.294**	**0.338**

TABLE G PERFORMANCE SUMMARY

GROUT	ACCEPTABILITY							
	SETTING TIME	EARLY VOLUME CHANGE	CHLORIDE PERMEABILITY	DRYING SHRINKAGE	COMMPRESSIVE STRENGTH	FREEZE-THAW DURABILITY	SALT SCALING	OVERALL PERFORMANCE (LISTING IN DS:133)
MASTERFLOW 713 GROUT	YES	YES	YES	YES	YES	YES	YES	YES
MASTER BUILDERS SET NON SHRINK GROUT	YES	YES	YES	YES	YES	YES	YES	YES
MEADOWS V-3 GROUT	YES	NO	YES	YES	YES	NO	NO	NO
MEADOWS V-1 GROUT	YES	NO	YES	YES	YES	NO	NO	NO
SIKA GROUT 212	YES	YES	YES	YES	YES	YES	YES	YES
STERNSON M-BED SUPER FLOW GROUT	YES	NO	YES	YES	YES	NO	NO	NO
STERNSON M-BED STANDARD GROUT	YES	YES	YES	YES	YES	YES	YES	YES
CC CHEMICALS IN-PAKT PRE-MIX GROUT	YES	YES	YES	YES	NO	NO	NO	NO
CPD NON-SHRINK GROUT	YES	YES	YES	YES	YES	YES	YES	YES
CPD NON-SHRINK GROUT WITH LATEX	YES	YES	YES	YES	NO	NO	YES	NO
SONOGROUT	YES	YES	YES	YES	YES	YES	YES	YES

APPENDIX A

MEMORANDUM

memorandum

To: Mr. R. Northwood,
Head, Concrete Section,
Central Building, Downsview.

Date: 86 04 03

SUBJECT: Grout for Bearing Anchor Holes and Bedding.

During the review of the proposed Special Provision OPS No. 191 (Bearings - Rotational and Sliding Surface) which requires non-shrink non-staining grout for bedding and filling anchor core-holes, concern was expressed that the grouts included in the MTC Designated Sources List may not be chloride resistant.

The Bearings Committee would like you to confirm that the non-shrink grouts included in the Designated Sources List are chloride resistant and non-staining (i.e. non-ferrous).

KGB/cf

K. G. Bassi,
Chairman,
Bearings Committee.

CONCRETE SECTION
REC'D.
APR 7 1986
ENGINEERING MATERIALS OFFICE

memorandum

CONCRETE SECTION
REC'D.
APR 9 1986
ENGINEERING MATERIALS OFFICE

To: Mr. R. Northwood,
Head, Concrete Section,
Central Building, Downsview.

Date: 86 04 08

SUBJECT: Grout for Bearing Anchor Holes and Bedding.

Further to my memo of 86 04 03, I would like to add that in case the grouts presently included in the MTC Designated Sources List are not chloride resistant and non-staining, the Bearings Committee would appreciate if you could provide us with a list of proprietory grouts or details of a non-proprietory grout mix that would be suitable for use as bedding material and filling anchor core-holes for bearings.

KGB/cf

K. G. Bassi,
Chairman,
Bearings Committee.

APPENDIX B

METHOD OF TEST FOR SCALING RESISTANCE OF CONCRETE SURFACES EXPOSED TO DEICING CHEMICALS

METHOD OF TEST
FOR SCALING RESISTANCE OF CONCRETE SURFACES EXPOSED TO DEICING CHEMICALS

1. SCOPE

1.1 This test method covers determination of the resistance to scaling of a horizontal concrete surface exposed to freezing and thawing cycles in the presence of deicing chemicals. It is intended for use in evaluating this surface resistance quantitatively by determining the dry mass of the flaked off concrete and qualitatively by visual examination.

2. RELEVANT DOCUMENTS

2.1 ASTM Designation C 192

2.2 ASTM Designation C 672

2.3 OPSS 1351

2.4 MTC Laboratory Testing Manual, Volume I

3. DEFINITION

3.1 Scaling is flaking or peeling away of the near surface portion of hardened concrete or mortar, or a thin layer of mortar flakes off the surface of coarse aggregate.

4. SIGNIFICANCE AND USE

4.1 This test method can be used to evaluate the effect of mix proportions, surface treatment, curing, or other variables on resistance to scaling.

4.2 This test method is also used to evaluate salt scaling resistance of slabs cut from hardened concrete such as barrier walls, precast manholes and noise barriers.

5. APPARATUS

5.1 FREEZING EQUIPMENT: A cabinet or room of sufficient size to hold specimens and capable of lowering the temperature of the specimens to $-18 \pm 2^{\circ}C$ within 16 to 18 hours and maintaining this temperature with a full load of specimens.

5.2 THAWING ROOM: A room or cabinet maintaining an air temperature of $23 \pm 2^{\circ}C$ and a relative humidity of $50 \pm 5\%$.

...2/-

5.3 SCALES: Scales for determining mass of batches of materials and concrete shall conform to the requirements of MTC Test Method LS-401.

5.4 BALANCE: A balance or scale having a minimum capacity of 5000 g and an accuracy of 0.1 g.

5.5 CONCRETE MIXER: A mixer complying with the requirements of MTC Test Method LS-401.

5.6 SLUMP CONE AND AIR METER: The apparatus shall comply with the requirements of MTC Test Method LS-402 and LS-403 (or LS-404), respectively.

5.7 MOULDS: Moulds shall be 300 x 300 x 75 mm in inside dimensions and have collars attached to form ledges for the installation of a precast dyke. They shall conform to the requirements of ASTM C 192. Moulds made of 19 mm thick plywood are acceptable provided that they are waterproofed to make them non-absorptive and leakproof.

5.8 TAMPING ROD: A round straight steel rod 16 mm in diameter and approximately 600 mm in length, having the tamping end rounded to a hemispherical tip of the same diameter as the rod.

5.9 DRYING OVEN: An oven capable of maintaining a temperature of 105 ± 2°C.

5.10 FILTER PAPER: Whatman No. 2, 320 mm in diameter or equivalent.

5.11 SMALL TOOLS: Wood strike-off board, 75 mm paint brush to provide the desired texture of the test surface, and a polyethylene sheet 350 x 350 mm, mounted on a plywood frame to cover the plastic concrete prior to placing in the moisture room.

6. PROPORTIONING AND MIXING

6.1 PROPORTIONING: The air content, cement content, water cement ratio, slump and other characteristics of the concrete and its ingredients shall be those appropriate for the purposes for which the tests are to be made.

6.2 MIXING: The mixing shall be in accordance with MTC Test Method LS-401.

6.3 TESTING PLASTIC CONCRETE: All the standard tests shall be carried out in accordance with MTC Test Method LS-401.

7. SPECIMENS

7.1 NUMBER OF SPECIMENS: At least two duplicate specimens, each 300 x 300 x 75 mm, shall be made for each test condition.

...3/-

7.2 FABRICATION OF SPECIMENS: Coat the inside surface of each mould with a light film of form oil just prior to fabrication of the specimens. Fill the mould in one layer and rod one time for each 1300 mm2 of surface (300 x 300 mm area requires 70 strikes of the rod), leaving a slight excess of material after the final rodding. Tap around the mould perimeter with a nylon tipped hammer to close any remaining voids and immediately screed excess concrete with a wood strike-off board and finish the surface with two passes of a wood float, one in each direction. After the concrete has stopped bleeding, finish the surface with three sawing-motion passes of a wood strike-off board. Brush the surface with a mediuim stiff brush as a final finishing operation to remove any laitance and to leave a slightly textured surface unless another method of surface finishing is to be evaluated. When the sheen of water has disappeared, gently brush the top surface with the paint brush to remove any laitance and to leave a slightly textured surface unless another method of surface finishing is to be evaluated.

7.3 SPECIMENS FROM HARDENED CONCRETE: Slabs obtained from hardened concrete shall have a test area approximately equal to the area of the cast specimens (7.1). The surface to be tested shall be free of any damage.

8. CURING AND DYKING

8.1 LABORATORY CAST SPECIMENS: Immediately after finishing the surface (7.2), cover the surface with a polyethylene sheet (5.11) and move the specimens into moist storage (23 ± 2°C, at least 95% R.H.). At 20 to 24 h after addition of water to the mix, remove the specimens from the moist storage, demould, identify each and return them to the moist storage. Remove the specimens from the moist storage at the age of 14 d and place them in air for 14 d at 23 ± 2°C and a relative humidity of 45-55%. During the dry storage period, apply an air entrained paste to the recessed ledges around the perimeter of the test specimen, then lower a precast air entrained mortar dyke into the recess (Fig. 1) and remove any excess paste. After allowing the paste to harden for 24 h, apply epoxy sealant to the inside, top and outside of the dyke extending the outside surface epoxy treatment to 25 mm below the joint.

8.2 SPECIMENS FROM HARDENED CONCRETE: Apply an epoxy bonding agent around the perimeter of the top surface of each specimen and cast a 20 x 20 mm epoxy mortar dyke, (Fig. 2). Allow the dyke to cure for 3 d at 23 ± 2°C and 45-55% relative humidity before starting the salt scaling test.

...4/-

9. TEST PROCEDURE

9.1 SALT SOLUTION: The deicing salt shall be a 3% solution of sodium chloride. The test surface shall be covered with approximately 6 mm of the solution.

9.2 FREEZE-THAW CYCLE: At the age of 28 d, cover the test surface with the salt solution and expose the specimens to continuous freeze-thaw cycling, each cycle consisting of 16-18 h in the freezing environment followed by storage at 23 ± 2°C and a relative humidity of 45-55% for 6-8 h. Add the salt solution before each freezing phase of the cycle as necessary to maintain the required depth.

During the test each specimen shall be supported by means of wood strips, to allow free air circulation under, around and over it (Fig. 1).

9.10 MASS LOSS: After each 5 cycles, remove the salt solution together with all the flaked off concrete from the surface and place into a watertight container. The operation is best accomplished by tilting the slab into a funnel approximately 500 mm in diameter and washing the surface of the specimen with the salt solution. The washing should continue until all loose particles are removed from the concrete. The solution shall then be strained through a filter and the residue dried out in an oven at 105°C to a constant mass condition. The residue shall be cumulatively weighed after each 5 cycles. This residue shall be defined as the loss of mass and expressed in kilograms per square metre of exposed slab area. The loss of mass shall be calculated to the nearest 0.01 kg/m2.

After the washing of each slab, the surface shall be covered with a new solution of sodium chloride.

9.11 VISUAL RATING OF SURFACE: After each 5 cycles, rate the test surface of each specimen in accordance with the following scale:

Rating	Condition of Surface
0	No scaling.
1	Very slight scaling (3 mm depth max., no coarse aggregate visible).
2	Slight to moderate scaling.
3	Moderate scaling (some coarse aggregate visible).
4	Moderate to severe scaling.
5	Severe scaling (coarse aggregate visible over entire surface).

...5/-

9.12 NUMBER OF CYCLES: Unless otherwise stated in the test program, terminate the test after exposure to 50 cycles.

10. **REPORT**

The report shall include the following:

10.1 Specimens fabricated in the laboratory.

- mix proportions
- source and type of each concrete ingredient
- slump and air content
- curing of specimens if other than standard
- area of the surface exposed to scaling (each slab)
- cumulative mass loss after each 5 cycles (each slab)
- visual rating of the surface after each 5 cycles (each slab)
- photographs of each slab at 0, 10, 25 and 50 cycles (if test is extended, photographs also required at completion of test)

10.2 Specimens from Hardened Concrete

- the size and shape of the specimen
- orientation of the specimen in the structure
- curing if other than standard
- area of the surface exposed to scaling (each slab)
- cumulative mass loss after each 5 cycles (each slab)
- visual rating of the surface after each 5 cycles (each slab)
- photographs of each slab at 0, 10, 25 and 50 cycles (if test is extended, photographs also required at completion of test)

...6/

11. GENERAL NOTES

11.1 If the method is used to evaluate a concrete coating or penetrating sealant, the sealant shall be applied during the dry storage period at the time and in the manner specified by the test program for the sealant. The treated specimens shall be exposed to the cycling at the time required by the test program.

11.2 Curing of the specimens may differ from the standard depending on the mix, e.g. latex mix. In such cases, the specimens are cured as required by the test program.

11.3 If there is any interruption in the daily cycling, the specimens shall be kept frozen.

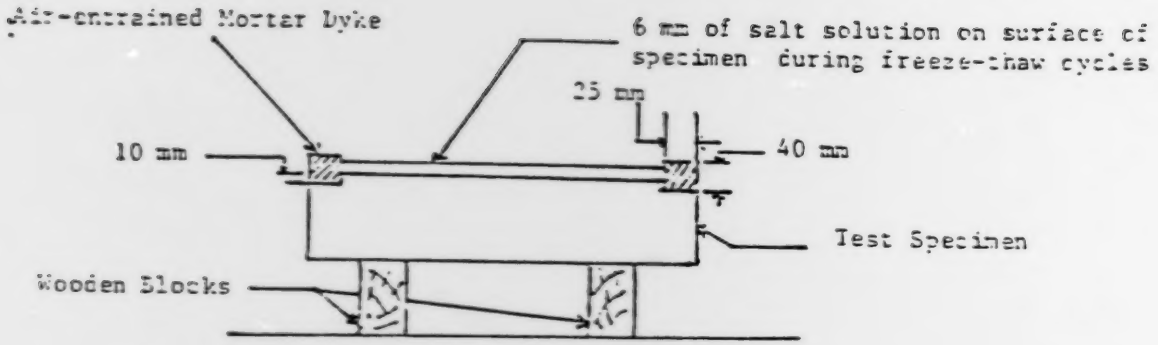
Air-entrained Mortar Dyke
6 mm of salt solution on surface of specimen during freeze-thaw cycles
25 mm
10 mm
40 mm
Test Specimen
Wooden Blocks

Fig. 1

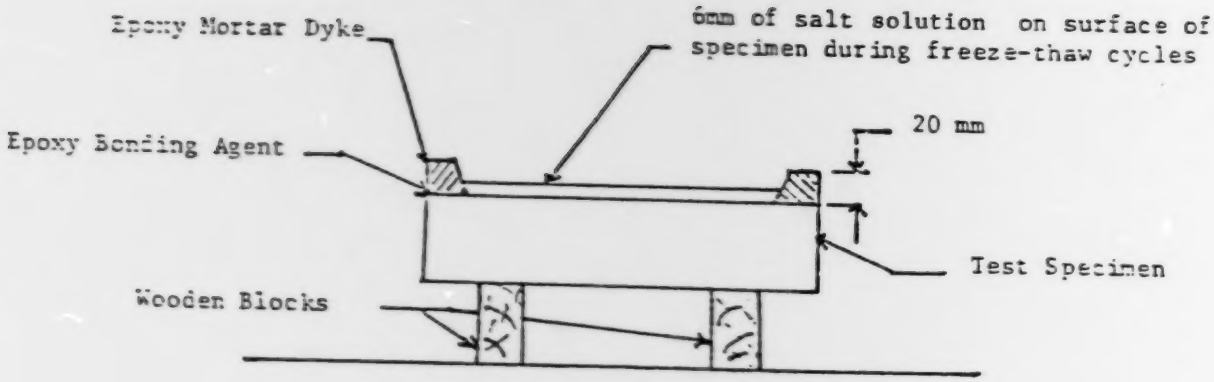
Epoxy Mortar Dyke
6mm of salt solution on surface of specimen during freeze-thaw cycles
20 mm
Epoxy Bonding Agent
Test Specimen
Wooden Blocks

Fig. 2